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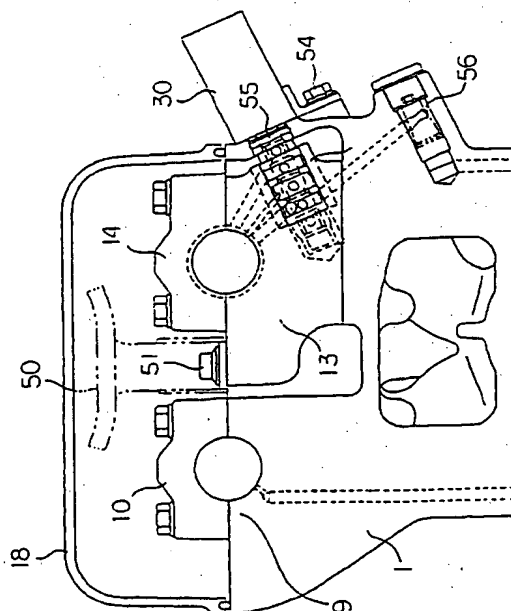
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(54) Four stroke internal combustion engine

(57) A four-stroke internal combustion engine comprising a cylinder head, a camshaft on an air intake side and a camshaft on an exhaust side of the engine, and a variable valve timing device fitted to at least one of the camshafts, characterized by an oil control valve for said variable valve timing device, said oil control valve projecting through a wall portion of the cylinder head and

being partially exposed to the outside of the cylinder head. Accordingly, an oil control valve can be attached to the camshaft supporting part without increasing the overall length of the engine and without compromising the securing of the cylinder-head bolts. Further, the oil control valve can be made easily serviced by exposing it on the outside of the engine without requiring a special seal component.

[Figure 8]



Description

[0001] The present invention relates to the field of four-stroke internal combustion engines comprising a variable valve timing device and in particular to a four-stroke internal combustion engine comprising a cylinder head, a camshaft on an air intake side and a camshaft on an exhaust side of the engine and a variable valve timing device fitted to at least one of the camshafts.

[0002] In a conventional four-stroke engine having a DOHC valve system - i.e. in a four-stroke engine wherein valve-operating camshafts driven by the rotation of a crankshaft are provided above the air intake valves and exhaust valves respectively - a variable valve timing device (VVT) which varies the phase angle of the camshaft relative to the cam sprocket by hydraulic control with an oil control valve is fitted to at least one of the camshafts on the air intake and/or exhaust side so as to vary the timing at which the air intake and/or exhaust valves are opened and closed according to the operating state of the engine.

[0003] In a four-stroke engine equipped with a variable valve timing device as mentioned above, any attempt to attach an oil control valve for supplying oil to the variable valve timing device to the camshaft supporting part of the cylinder head located in the vicinity of the variable valve timing device will cause the width of said camshaft supporting part to increase and will thus cause the engine as a whole to become longer in the front-to-back direction (i.e. the axial direction of the camshaft).

[0004] In other words, since the camshaft supporting part located at the front end part of the engine is formed as an integral part of the cylinder head, the overall front-to-back length of the engine increases due to the distance between the variable valve timing device and the cylinder-head bolts - which connect the cylinder head to the cylinder block in the vicinity of the front end part of the engine away from said camshaft supporting part - increasing by an amount equal to the increase in width (front-to-back length) of the camshaft supporting part located at the front end part of the engine.

[0005] Moreover, if an attempt is made to overlap the camshaft supporting part located at the front end part of the engine to which the oil control valve is attached with the attachment position of the cylinder-head bolt in plan view - i.e. by passing the cylinder-head bolts through said camshaft supporting part - the distance between the cylinder-head bolts and the variable valve timing device does not increase, but said camshaft supporting part can easily become deformed if the cylinder-head bolts are tightly fastened and it is thus impossible to ensure that the cylinder-head bolts can be fastened securely enough to achieve a firm connection between the cylinder block and cylinder head.

[0006] The present applicant has investigated a solution to such problems whereby a camshaft supporting part provided with an oil control valve and its associated oil passages is formed as a cam carrier that is a separate

member from the cylinder head, and said cam carrier is linked to the cylinder head from above the cylinder-head bolts linking the cylinder head to the cylinder block so as to overlap the cylinder-head bolts in plan view, thereby allowing the cylinder-head bolt to be securely fastened while avoiding any increase in the overall front-to-back length of the engine.

[0007] However, the serviceability of the oil control valve is impaired when the oil control valve is attached to a cam carrier disposed inside the cam chamber enclosed by the cylinder-head cover so as to accommodate the entire oil control valve inside the cam chamber, and when the oil control valve is attached to the cam carrier in such a way that the top part thereof is exposed through the cylinder-head cover, a special seal component must be provided in the part of the cylinder-head cover in which the oil control valve is inserted.

[0008] Besides, when the oil control valve is attached to the cam carrier through the cylinder-head cover in a sealed state, the oil control valve is partially bound by the cylinder-head cover which is easily affected by vibration so that the cylinder-head cover causes the oil control valve to vibrate relative to the cam carrier, with the resulting danger of adversely affecting the valve part of the oil control valve attached to the cam carrier.

[0009] The present invention is directed at solving the abovementioned problems; specifically, it is an objective of the invention to provide a four-stroke engine equipped with a variable valve timing device, in which engine an oil control valve can be attached without increasing the overall length of the engine and to facilitate the servicing of the oil control valve.

[0010] According to the present invention, this objective is solved in an inventive manner for a four-stroke internal combustion engine as indicated above by an oil control valve for said variable valve timing device, said oil control valve projecting through a wall portion of the cylinder head and being partially exposed to the outside of the cylinder head.

[0011] Further advantageous embodiments are laid down in the subclaims.

[0012] The invention will now be described in greater detail with reference to the accompanying drawings showing by means of example preferred embodiments. Therein:

Figure 1 is a top view of a four-valve multi-cylinder engine relating to one embodiment of the four-stroke engine equipped with a variable valve timing device according to the present invention, showing the vicinity of the front end part of the engine with the cylinder head cover taken off and the air intake/exhaust valves and spark plugs removed.

Figure 2 is a top view showing a partial cross-section along the upper surface of the cylinder head.

der head of the variable valve timing device and each camshaft, with the cam caps and chain guide further removed from the engine parts shown in Figure 1.

Figure 3 is a front view of a cam carrier which supports the front end part of the air intake cam to which is attached a variable valve timing device in the engine parts shown in Figure 1, illustrating the structure of this cam carrier.

Figure 4 is a top view of the cam carrier shown in Figure 3

Figure 5 is an explanatory front view showing how each member is connected in the engine parts shown in Figure 1.

Figure 6 is an explanatory side view showing how each of the members in Figure 5 is connected

Figure 7 is a cross sectional view along A-A line of Figure 1 showing how the chain guide, which connects the top surface of the cam carrier with the top surface of the cylinder head is attached

Figure 8 is an explanatory front view of the engine parts shown in Figure 1 showing how the oil filter and oil control valve are disposed, and showing the oil passages whereby oil is supplied from the cylinder block to each camshaft

Figure 9 is a top view of a five-valve multi-cylinder engine relating to another embodiment of the present invention showing the vicinity of the front end part of the engine with the cylinder head cover taken off and with parts such as the air intake/exhaust valves, spark plugs, cam caps and chain guide removed and

Figure 10 is an explanatory side view showing the axes of the air intake valves and the axis of the oil control valve on the air intake side of the engine parts shown in Figure 9.

[0013] With regard to a 4-valve multi-cylinder engine relating to one embodiment of the present invention, Figure 1 is a top view of the vicinity of the front end part of the engine with the cylinder head cover removed and without the air intake/exhaust valves or spark plugs, and Figure 2 shows the same assembly as in Figure 1 from which the cam cap and chain guide have also been excluded, providing a cross-sectional view of the variable

valve timing device and the camshafts along the upper surface of the cylinder head.

[0014] In cylinder head 1 of the 4-valve multi-cylinder engine, which is provided with two air intake valves and two exhaust valves per combustion chamber in each cylinder, a cylindrical aperture 2 for spark plug mounting is formed at the center of every combustion chamber ceiling plate part of each cylinder, and two cylindrical apertures 3 for air intake valve mounting and two cylindrical apertures 4 for exhaust valve mounting are formed on both sides thereof.

[0015] An air intake camshaft 5 for driving the air intake valves is disposed above each of the apertures 3, 3 formed in cylinder head 1 for mounting the air intake valves, and an exhaust camshaft 6 for driving the exhaust valves is disposed above each of the apertures 4, 4 for mounting the exhaust valves; these camshafts are disposed parallel to each other, with a gap between them, and parallel with the cylinder layout orientation (i.e. the crankshaft axial direction), but vertical to the axis of the cylinders.

[0016] In order to support each of these camshafts 5 and 6, camshaft supporting parts 7, 7 - which are formed at the upper surface of the lower half of the journal bearing part - are both integrally formed as a part of cylinder head 1 at both sides of the apertures 2 for spark plug mounting in each cylinder, i.e. between the apertures 3, 3 for mounting the air intake valves and between the apertures 4, 4 for exhaust valve mounting, respectively as shown in Figure 2.

[0017] Each cam cap 8, 8 is integrally linked to each camshaft supporting part 7, 7 on both sides of aperture 2 for spark plug mounting as shown in Figure 1 by screwing a bolt that passes through cam cap 8 into a screw hole formed in camshaft supporting part 7, and each camshaft 5, 6 is supported with rotational freedom by supporting it with the lower half of a journal bearing formed in the upper surface of camshaft supporting part 7 and with the upper half of a journal bearing formed in the lower surface of cam cap 8.

[0018] The front end part of exhaust camshaft 6 is supported with rotational freedom by a camshaft supporting part 9 integrally formed at the front end part of cylinder head 1 and by a cam cap 10 connected above it, and a cam sprocket 11 is integrally fixed to the front end of exhaust camshaft 6 by a bolt 12.

[0019] The front end part of air inlet camshaft 5 is held with rotational freedom by a camshaft supporting part 13 integrally linked to the front end part of cylinder head 1 and by a cam cap 14 connected above it, and a variable valve timing device 20 with a cam sprocket 15 formed around its outside is integrally attached to the front end of air inlet camshaft 5 by a bolt 16.

[0020] An endless cam chain 17 is wrapped around the cam sprocket 15 formed around the outside of variable valve timing device 20 and the cam sprocket 11 fixed to the front end part of exhaust cam 6, and this chain also extends around a drive sprocket (not illustrat-

ed); as cam chain 17 is driven around by the crankshaft rotation via the drive sprocket, the air intake camshaft 5 and exhaust camshaft 6 are rotationally driven via variable valve timing device 20 and cam sprocket 11 respectively, and the engine's air intake valves and exhaust valves are opened and closed at prescribed timings according to the rotational driving of camshafts 5 and 6.

[0021] As Figure 6 shows, the region above cylinder head 1, including the region occupied by variable valve timing device 20, is covered by a cylinder-head cover 18, and below cylinder-head cover 18 the front side of the engine where cam chain 17 is fitted is also covered by a chain cover 19 extending over a region from cylinder head 1 to the cylinder block (not illustrated).

[0022] The variable valve timing device 20 attached to the front end part of air intake camshaft 5 is of a hitherto known construction, and as shown in Figure 2, the cover member 21 and boss member 22 of said device 20 are integrally fixed to the front end of air intake camshaft 5 with a bolt 16, and a housing member 23 is provided so as to be capable of relative rotational motion with respect to boss member 22, cam sprocket 15 being integrally formed around the outside of this housing member 23.

[0023] Inside housing member 23, a piston member 24 that surrounds boss member 22 is provided so as to be able to move along the axial direction of camshaft 5 while remaining spline-fitted to the outer surface of boss member 22 and engaged by a helical gear with the inner surface of housing member 23, and piston member 24 - which can thus slide relative to boss member 22 without rotating, and which moves in a spiral fashion relative to housing member 23 - is pressed toward cover member 21 by a coil spring 25 provided between it and boss member 22.

[0024] The hollow part inside housing member 23 is sectioned into two oil chambers 26, 27 by piston member 24, with an oil passage 28 which passes through boss member 22 from air intake camshaft 5 connecting with one oil chamber 26, and an oil passage 29 which passes through boss member 22 from air intake camshaft 5 connecting with the other oil chamber 27; an oil control valve 30, which is described below, sends oil into either one of these oil passages 28, 29 and sends oil out from the other.

[0025] With a variable valve timing device 20 constructed in this way, piston member 24 is slid along boss member 22 as oil is supplied by oil passages 28, 29 to one of the oil chambers 26, 27 and discharged from the other, causing piston member 24 to move in the axial direction of camshaft 5 and thereby turning housing member 23 so that housing member 23 is turned relative to boss member 22.

[0026] This results in a change in the phase angle between cam sprocket 15, which is formed integrally with housing member 23 of variable valve timing device 20, and air intake camshaft 5, which is integrally fixed to boss member 22, and since the phase angle between

air intake camshaft 5 and cam sprocket 15 is changed in this way, the timing with which the air intake valves are opened and closed by the rotation of air intake camshaft 5 is either advanced or delayed according to the operating state of the engine.

[0027] Incidentally, in the four-stroke engine of the present embodiment wherein a variable valve timing device 20 is fitted to the front end of air intake camshaft 5 as described above, camshaft supporting part 9 - which supports the front end part of exhaust camshaft 6 to which a simple cam sprocket 11 is fixed - is integrally formed as a part of cylinder head 1, whereas camshaft supporting part 13 - which supports the front end part of air intake camshaft 5 to which variable valve timing device 20 is fitted - is formed as a cam carrier, which is a separate member to cylinder head 1, and is integrally linked to cylinder head 1.

[0028] Figure 3 and Figure 4 show the configuration of the camshaft supporting part 13, i.e. cam carrier 13, which supports the front end part of air intake camshaft 5 to which the variable valve timing device 20 is fitted; Figure 3 is a front view, and Figure 4 is a top view.

[0029] Cam carrier 13, which constitutes the camshaft supporting part of air intake camshaft 5, is formed by a journal bearing part (lower half) 31 which supports the front end journal part of air intake camshaft 5, and - below that - a valve attachment part 32 for attaching the valve parts of oil control valve 30; cam carrier 13 is also formed with a pinhole 33 for locating it against cylinder head 1, and with pinholes 34, 34 for locating cam carrier 13 against cam cap 14, and bolt through-holes 35, 35 are also formed to link cam carrier 13 to cylinder head 1 while also securing cam cap 14.

[0030] Also, an oil passage 37 which connects with the oil passage 28 of air inlet camshaft 5 via an annular slot 36 formed in journal bearing part 31, an oil passage 39 which connects with the oil passage 29 of air inlet camshaft 5 via an annular slot 38 formed in journal bearing part 31, and an oil passage 40 for supplying lubricating oil to journal bearing part 31 are respectively formed between journal bearing part 31 and valve attachment part 32.

[0031] Furthermore, in the present embodiment, bolt hole 41 which is used to attach the chain guide is formed at the upper surface of cam carrier 13 so that chain guide 50 - which guides cam chain 17 in the state shown in Figure 1 and Figure 7 - is attached extending from the upper surface of cam carrier 13 to the upper surface of cylinder head 1.

[0032] With regard to the front end part of the engine where cam carrier 13 is integrally linked to cylinder head 1 as mentioned above, Figure 5 is a front view showing how each part is connected together, Figure 6 is a side view showing how each part is connected together, Figure 7 is a cross section along line A-A in Figure 1 showing how the cam carrier and chain guide are linked, and Figure 8 is a front view showing the arrangement of the oil control valves, the oil filter, and each oil passage.

[0033] As shown in Figure 5, camshaft supporting part 9, which supports the front end part of exhaust camshaft 6 to which cam sprocket 11 is fixed, is integrally formed as a part of cylinder head 1, whereas cam carrier 13, which supports the front end part of air intake camshaft 5 which is fitted with variable valve timing device 20, is formed as a separate member from cylinder head 1, and when it is located on cylinder head 1 by a pin inserted into pin hole 33 and used to locate cam cap 14 by pins inserted into pin holes 34, 34, it is secured together with cam cap 14 by bolts 45 passing through bolt through-holes 35, 35, thereby integrally linking it to cylinder head 1.

[0034] As shown in Figures 1 and 6, cam carrier 13, which is linked to cylinder head 1 in this way, is disposed so that in plan view it overlaps the cylinder-head bolts 46 for linking cylinder head 1 to the cylinder block (not illustrated), and after cylinder-head bolts 46 have been secured to link cylinder head 1 to the cylinder block, it is fastened together with cam cap 14 by bolts 45 and linked to cylinder head 1.

[0035] Moreover, in the present embodiment, chain guide 50 which guides cam chain 17 is fixed by bolts 51 and 52 at its attachment base part so as to connect the upper surface of cam carrier 13 and the upper surface of cylinder head 1 to cam carrier 13 which is linked by bolt 45 to cylinder head 1 as shown in Figure 1 and Figure 7, whereby the link between cam carrier 13 and cylinder head 1 is reinforced so that cam carrier 13 does not lean forward.

[0036] With respect to cam carrier 13 which is linked to cylinder head 1 as described above, the valve part of oil control valve 30 of variable valve timing device 20 is attached to valve attachment part 32 of cam carrier 13 as shown in Figure 8 by passing it through the wall part of cylinder head 1 so that parts of the main body for operating the valve parts according to signals from the ECU are exposed at the exterior of cylinder head 1, in which state it is fixed to cylinder head 1 by a bolt 54, and the inserted part of oil control valve 30 is sealed by an ordinary O-ring member 55 in the wall part of cylinder head 1.

[0037] Oil filter 56, which filters the oil supplied to said oil control valve 30, is attached to the oil control valve 30 fitted in the above manner so that it is partially exposed at the exterior of cylinder head 1 at a part below cam carrier 13 of cylinder head 1, and the oil supplied from the cylinder block is supplied to oil control valve 30 through oil filter 56.

[0038] With the four-stroke engine of the present embodiment, where the front end part of the air intake cam - which is fitted with a variable valve timing device 20 in the above way - is supported by a cam carrier 13 formed as a separate member to cylinder head 1, the cylinder-head bolt 46 that links the cylinder head to the cylinder block can be tightly secured without affecting cam carrier 13 to which the oil control valve 30 of variable valve timing device 20 is attached, and it is thus possible to

ensure that cylinder-head bolt 46 is able to establish a firm link between cylinder head 1 and the cylinder block.

[0039] Also, by forming cam carrier 13 as a separate member to cylinder head 1 and disposing it so as to overlap the attachment position of cylinder-head bolt 46 in plan view, the distance between cylinder-head bolt 46 and variable valve timing device 20 does not increase, even when cam carrier 13 is made wider through the attachment of oil control valve 30 to cam carrier 13, and thus there is no increase in the overall front-to-back length of the engine.

[0040] Also, with respect to the cam carrier 13 accommodated inside the cam chamber, by attaching oil control valve 30 to said cam carrier 13 so that it passes through the wall part of cylinder head 1 and is partially exposed to the outside, oil control valve 30 can be serviced easily without removing head cover 18, and furthermore, the insertion part of oil control valve 30 can easily be sealed with an ordinary O-ring member 55 so there is no need for a special seal component.

[0041] Furthermore, since the oil control valve 30 attached to cam carrier 13 is also fixed to cylinder head 1, oil control valve 30 does not vibrate relative to the cam carrier 13 fixed to cylinder head 1.

[0042] Also, in the present embodiment, oil control filter 56 - which filters the oil supplied to oil control valve 30 - is attached to cylinder head 1 in such a way that it is partially exposed at the outside thereof, so that oil filter 56 can also be serviced easily.

[0043] Although one embodiment of a four-stroke engine having a variable valve timing device according to the present invention has been described above, the present invention is not limited to the above embodiment and can also be applied to engines with different numbers of intake and exhaust valves per cylinder, for example, or to engines where a variable valve timing device is fitted to the exhaust camshaft instead of the air intake camshaft, or to engines where variable valve timing devices are fitted to both the air intake and exhaust camshafts, as e.g. shown in Fig. 9.

[0044] Figure 9 is a top view of a five-valve engine having 3 air intake valves and 2 exhaust valves, wherein variable valve timing devices are fitted both to the air intake camshaft and the exhaust camshaft respectively, showing the vicinity of the front end part of the engine with the cover taken off and parts such as the air intake and exhaust valves, spark plugs, cam caps and chain guide removed, and Figure 10 is a side view showing the central axes of the oil control valves 30 and each of the air intake valves on the air intake side of the engine shown in Figure 9.

[0045] In an engine fitted with variable valve timing devices 20, 20 both on air intake camshaft 5 and on exhaust camshaft 6 as shown in Figure 9, one cam carrier 13 which supports the front end parts of both air intake camshaft 5 and exhaust camshaft 6 is formed as a separate member from cylinder head 1, and is connected to the front end part of cylinder head 1, and oil control

valves 30 are attached to this cam carrier 13 on the air intake and exhaust sides respectively.

[0046] On the air intake side of a 5 valve engine with 3 air intake valves and 2 exhaust valves as shown in Figure 9, where a single cylinder is provided with three air intake valves, the axes B1 and B3 of the air intake valves on either side are inclined as shown in Figure 10 so as to converge toward the axis B2 of the central air intake valve at a point below the valves, and the axis C of oil control valve 30 on the air intake side is inclined so that it diverges from the axis B1 of the neighboring air intake valve toward the bottom thereof, so that any increase in the overall front-to-back length of the engine can be kept as small as possible without having the oil control valve 30 interfere with the lifter retaining part of cylinder head 1, and without the attachment position of oil control valve 30 coming too close to the chain chamber in the wall part of cylinder head 1.

[0047] In other words, the axis C of the oil control valve 30 is inclined with respect to a plane vertical to the axis of the camshafts 5, 6 to the rear end of the engine (away from the valve timing device 20) in its course from the inner and lower end of the oil control valve 30 to the exterior upper end thereof, as shown in Fig. 10. Additionally, the axis C of the oil control valve 30 may be inclined, as e.g. shown in Fig. 5, in a way that it rises upwards to the engine top from the center of the engine to the outside of the engine.

[0048] As described above, the axis C is inclined in two directions with respect to the main engine construction planes or axes. The incline of two opposite axes C located on the intake and exhaust side of the engine may be symmetrical to a vertical center plane set centered between the intake and exhaust camshafts or a plane laid through all cylinder axes.

[0049] Furthermore, with regard to a four-stroke engine equipped with a variable valve timing device according to the present invention, it goes without saying that appropriate modifications can be made to the design; for example, instead of using a cam carrier that is a separate entity from the cylinder head for the camshaft supporting parts that support the front end part of a camshaft, it could also be implemented in such a way that all the camshaft supporting parts are configured as a single member connecting them together in a ladder configuration as a cam carrier separate from the cylinder head.

[0050] With a four-stroke engine equipped with a variable valve timing device according to the present invention as described above, it is possible to attach an oil control valve to the camshaft supporting part of the camshaft to which the variable valve timing device is fitted without increasing the overall length of the engine or compromising the fastening of the cylinder-head bolts, and it is possible to ensure that the oil control valve can be easily serviced by exposing the oil control valve on the outside of the engine while keeping it firmly held in place.

Claims

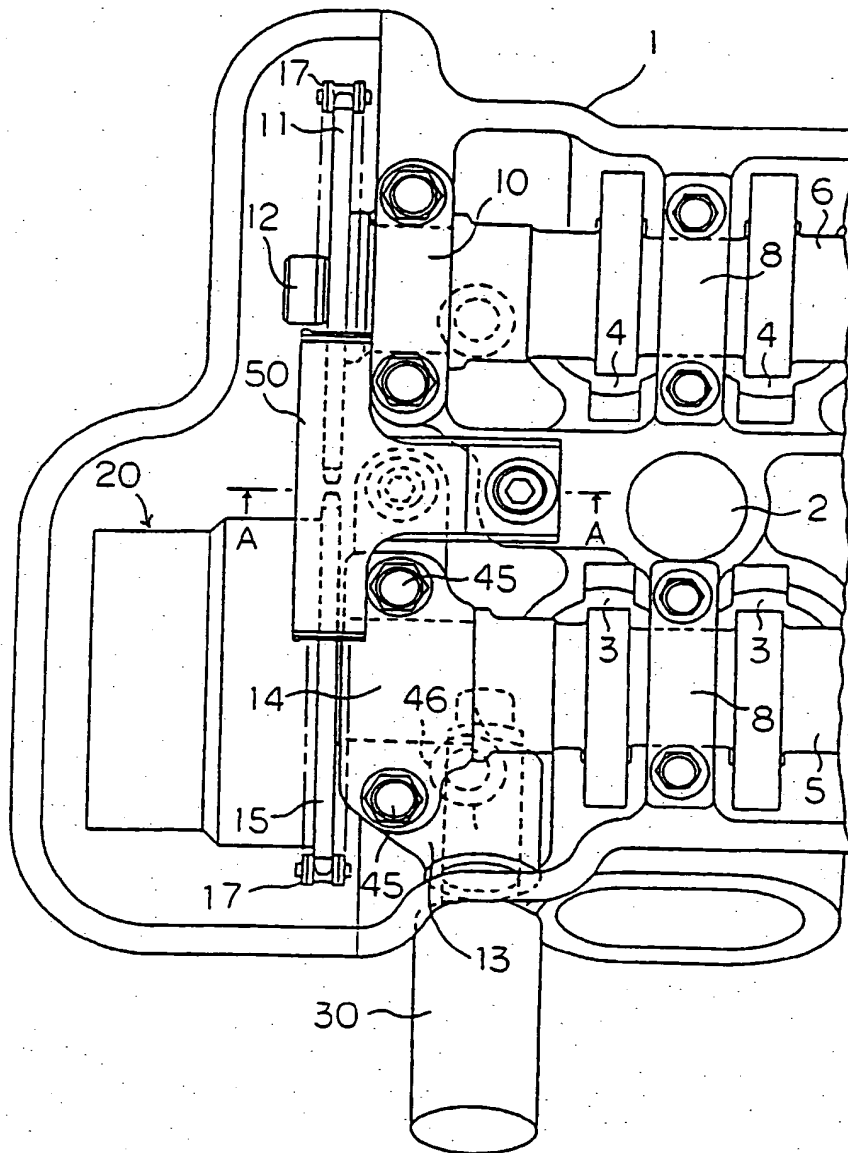
1. A four-stroke internal combustion engine comprising a cylinder head (1), a camshaft (5) on an air intake side and a camshaft (6) on an exhaust side of the engine, and a variable valve timing device (20) fitted to at least one of the camshafts (5;6),
characterized by
an oil control valve (30) for said variable valve timing device (20), said oil control valve (30) projecting through a wall portion of the cylinder head (1) and being partially exposed to the outside of the cylinder head (1).
2. Four-stroke internal combustion engine according to claim 1, **characterized in that** an axis C of said oil control valve (30) is inclined relative to the axis of the at least one camshaft (5,6) and/or to the axis of a cylinder.
3. Four-stroke internal combustion engine according to claim 1 or 2, **characterized in that** two or more air intake and/or exhaust valves are provided per a cylinder and that the oil control valve (30) is attached on the side of the camshaft on which the variable valve timing device (20) is located at an inclined angle in such a way that the axis of the oil control valve (30) diverges from the axis of the neighboring air intake valve or exhaust valve toward the bottom thereof.
4. Four-stroke internal combustion engine according to one of claims 1 to 3, characterized in that each cylinder is provided with three air intake valves and in that the axes (B1 and B3) of the side valves are inclined with respect to the axis (B2) of the central valve so as to converge at a point below the valves.
5. Four-stroke internal combustion engine according to one of claims 1 to 4, characterized by a camshaft supporting part (13) supporting at least one camshaft (5,6) in the vicinity of the variable timing device (20) and being separate from the cylinder head (1).
6. Four-stroke internal combustion engine according to claim 5, **characterized in that** said camshaft supporting part (13) is connected to said cylinder head (1) in a way that it overlaps at least one head bolt (46) linking said cylinder head (1) to a cylinder block in plan view.
7. Four-stroke internal combustion engine according to one of claims 1 to 6, **characterized in that** said camshaft supporting part (13) comprises a journal bearing part (31) for supporting a camshaft portion and a valve attachment part (32) for said oil control valve (30), wherein the valve attachment part is arranged outside the circumference of the journal

bearing part (31) when viewing in the axial direction of the camshaft.

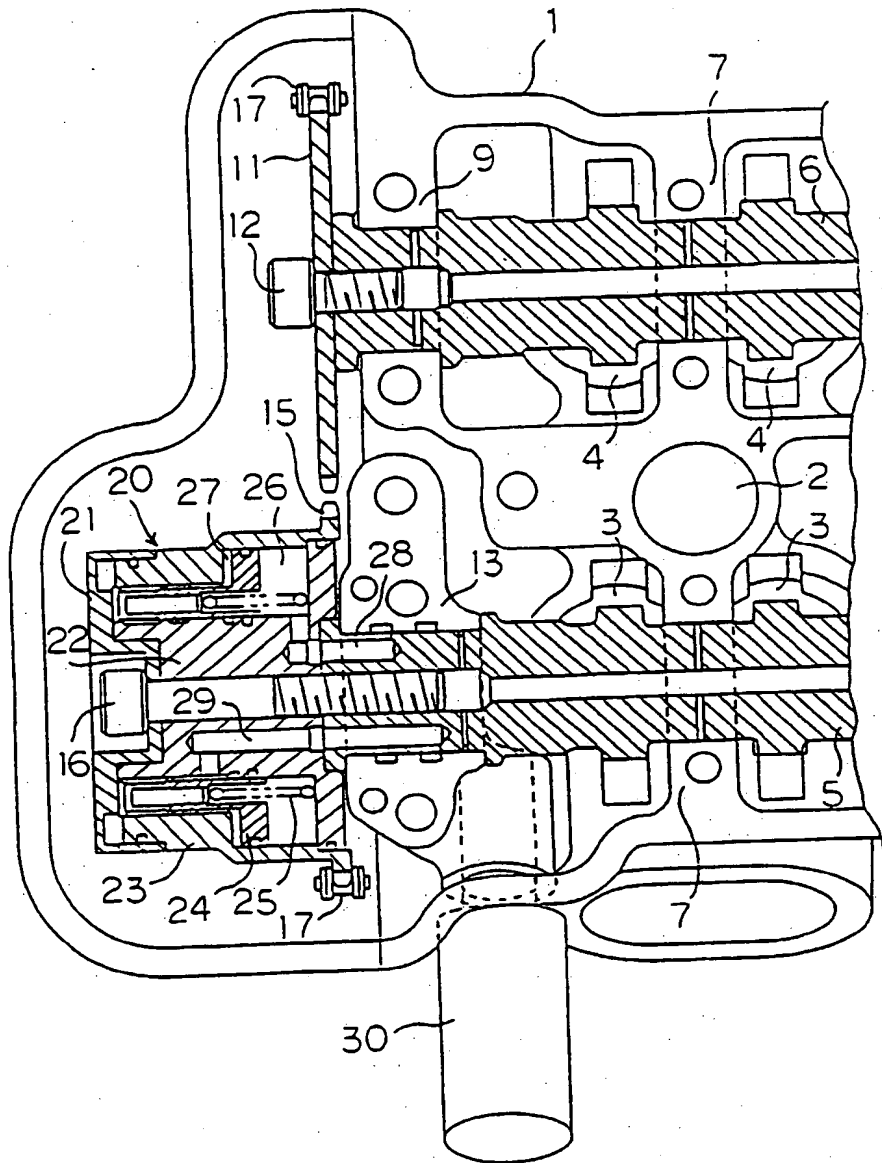
8. Four-stroke internal combustion engine according to claim 7, **characterized in that** said camshaft supporting part (13) is provided with through holes (35) for mounting it on the cylinder head (1), and that said valve attachment part (32) is arranged in front of or behind said through holes (35) with respect to the axial direction of the camshaft. 5 10
9. Four-stroke internal combustion engine according to one of claims 7 to 8, **characterized in that** said camshaft supporting part (13) terminates in an abutment surface for supporting the oil control valve (30) in an upwardly inclined position. 15
10. Four-stroke internal combustion engine according to one of claims 7 to 9, **characterized in that** said valve attachment part (32) is arranged on the side of the through holes (35) opposite to the valve timing device (20) mounted at one end of the at least one camshaft. 20
11. Four-stroke internal combustion engine according to one of claims 1 to 10, **characterized in that** each of the camshafts (5;6) is provided with a valve timing device (20) and oil control valve (30), respectively, said valve timing devices (20) being arranged on the same side of the cylinder head (1), while the respective control valves (30) are arranged on opposite sides with respect to the camshaft axes. 25 30
12. Four-stroke internal combustion engine according to one of claims 1 to 11, **characterized by** a chain guide member (50) guiding a cam chain (17) in a section between a cam sprocket (11) of said exhaust camshaft (6) and a cam sprocket (15) of said intake camshaft (5), being fixed at its attachment base part so as to connect the upper surface of said cam carrier (13) and the upper surface of said cylinder head (1). 35 40
13. Four-stroke internal combustion engine according to one of claims 1 to 12, **characterized in that** said oil control valve (30) attached to said cam carrier (13) is also fixed to said cylinder head (1) in a detachable manner, e.g. by means of bolts (54). 45
14. Four-stroke internal combustion engine according to one of claims 1 to 13, **characterized in that** a sealing means (55) is arranged between the oil control valve (30) and the wall portion of the cylinder head (1) through which the oil control valve projects outwards and in that said sealing means (55) may be a regular O-ring. 50 55
15. Four-stroke internal combustion engine according

to one of claims 1 to 14, **characterized in that** an oil filter (51) for filtering oil supplied to the oil control valve (30) is attached to the cylinder head (1) in such a way that it is partially exposed at the outside of the cylinder head (1).

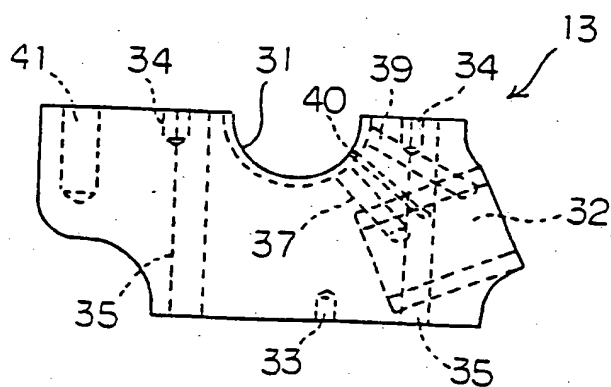
[Figure 1]



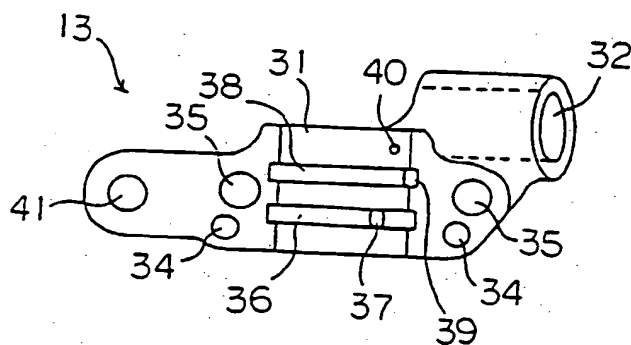
[Figure 2]



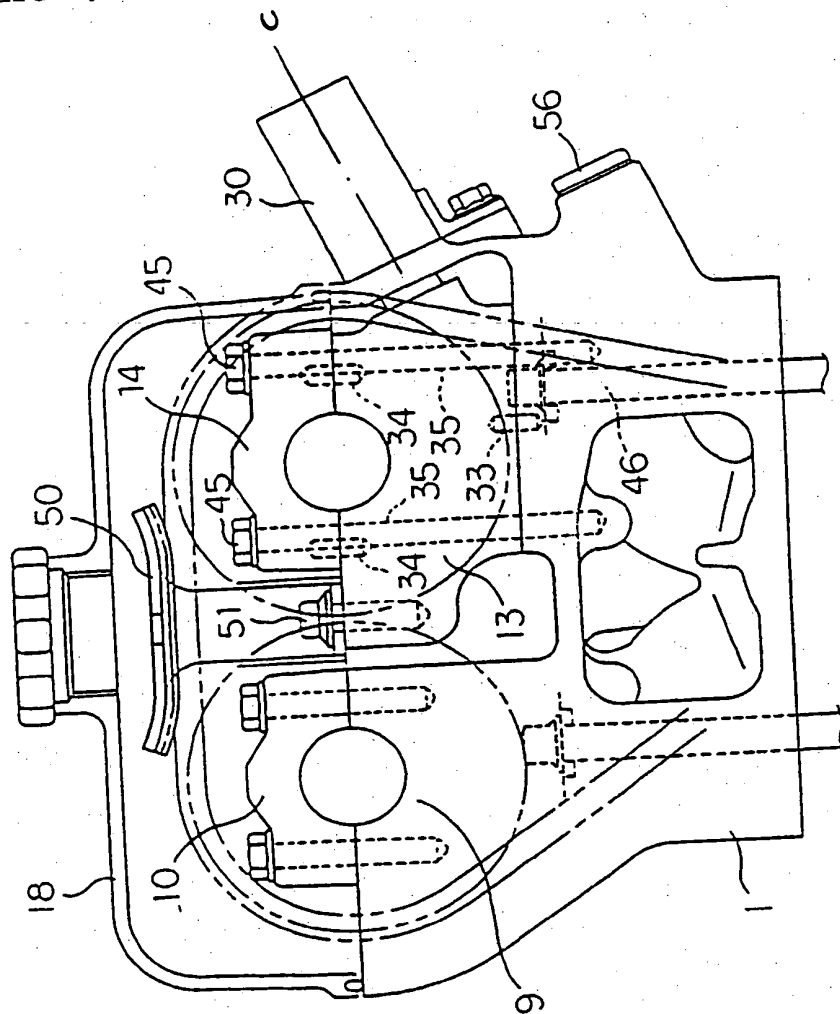
[Figure 3]



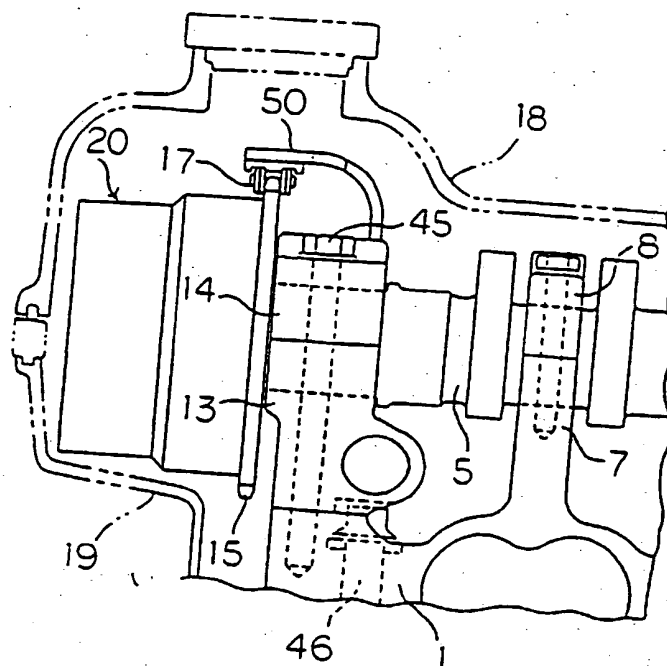
[Figure 4]



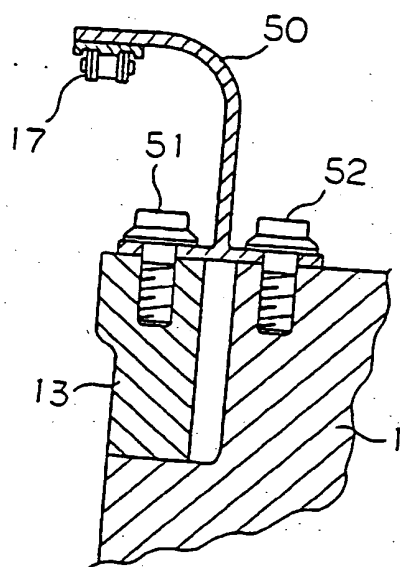
[Figure 5]



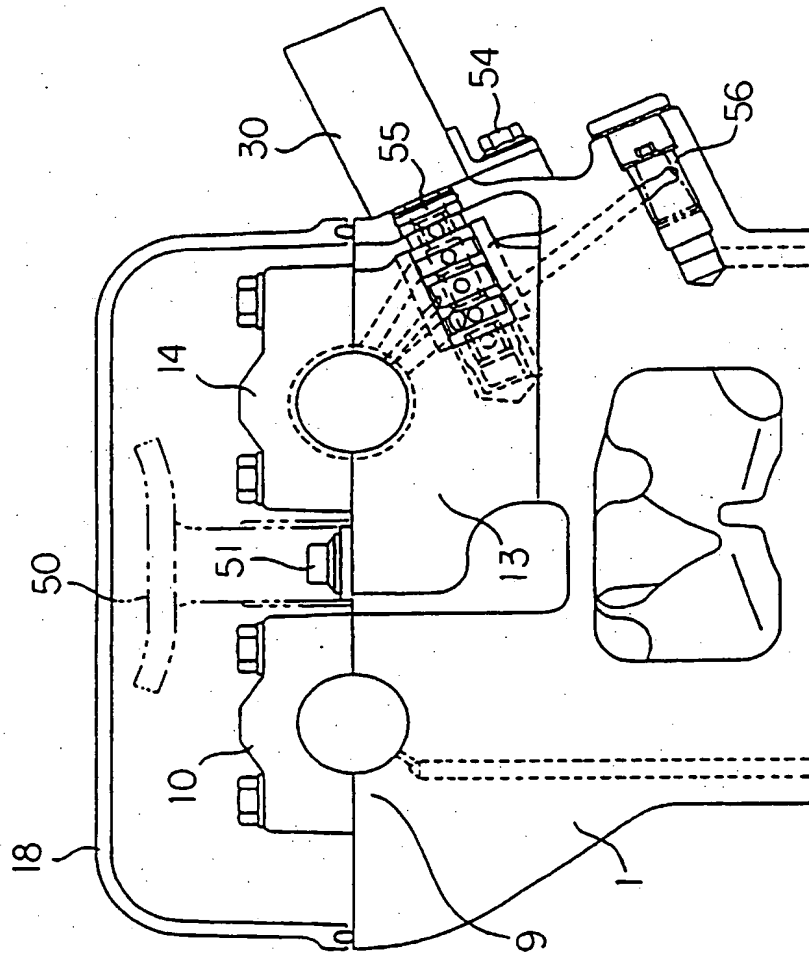
[Figure 6]



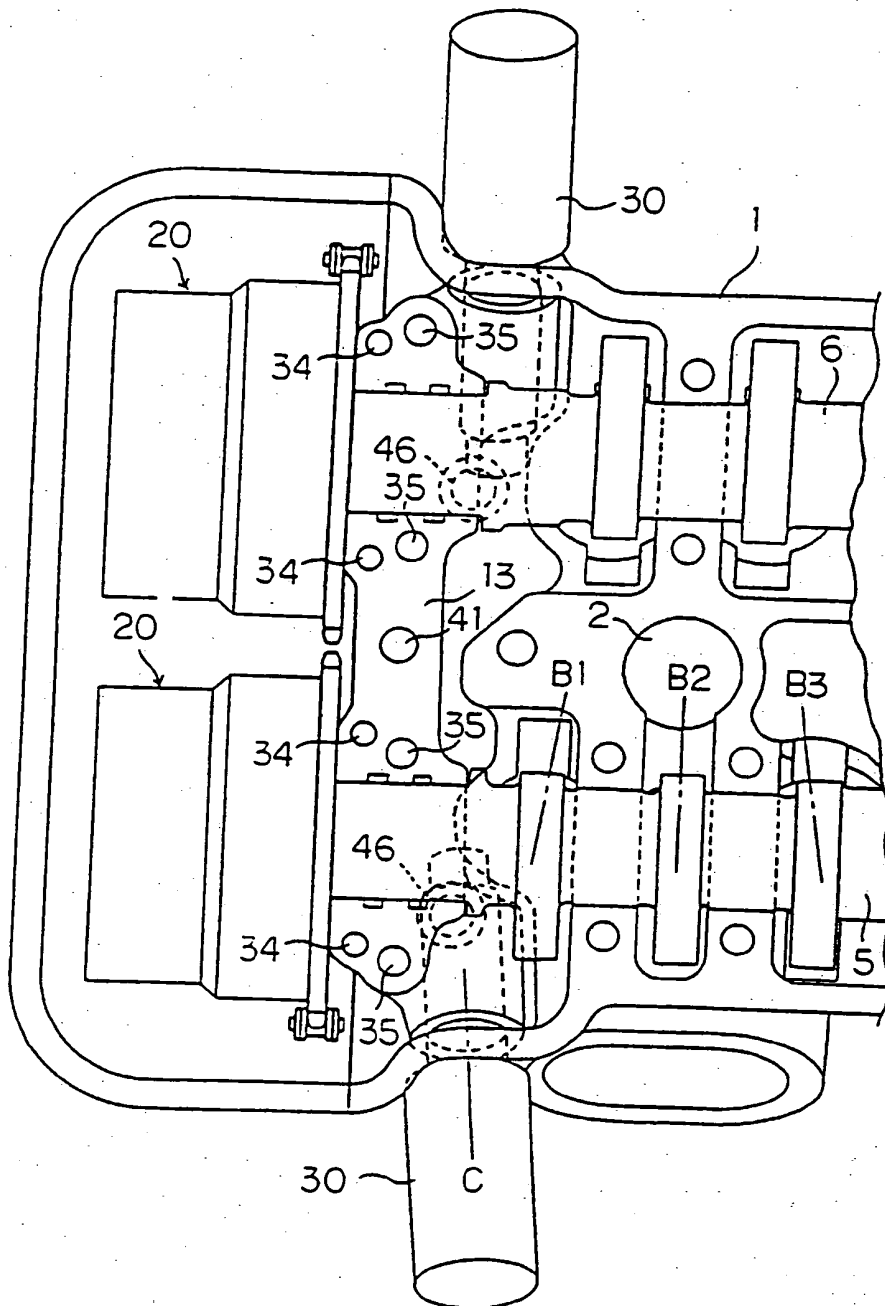
[Figure 7]



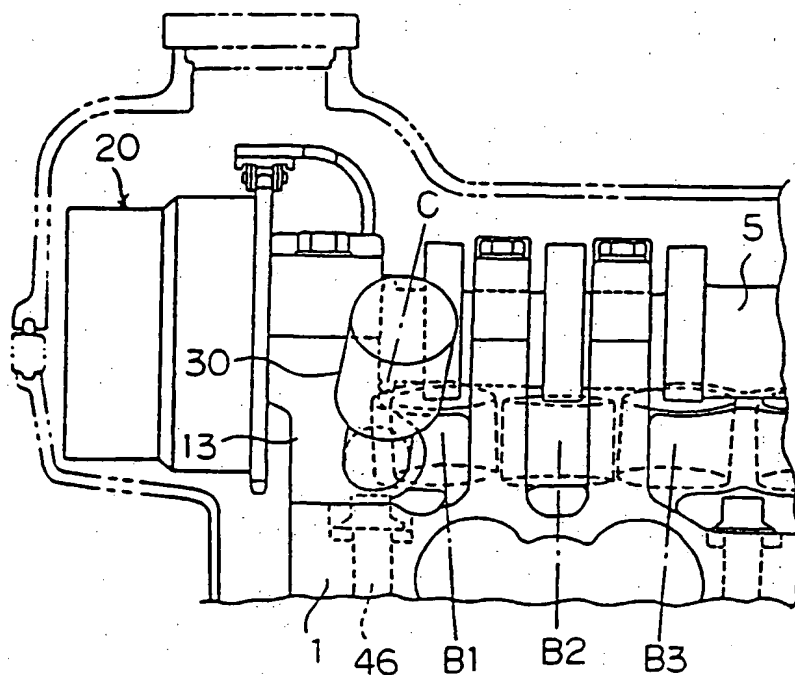
[Figure 8]

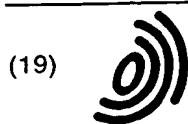


[Figure 9]



[Figure 10]





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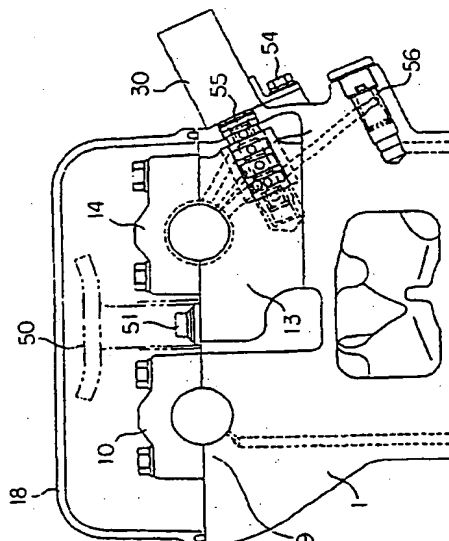
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(54) **Four stroke internal combustion engine**

(57) A four-stroke internal combustion engine comprising a cylinder head, a camshaft on an air intake side and a camshaft on an exhaust side of the engine, and a variable valve timing device fitted to at least one of the camshafts, characterized by an oil control valve for said variable valve timing device, said oil control valve projecting through a wall portion of the cylinder head and being partially exposed to the outside of the cylinder head. Accordingly, an oil control valve can be attached to the camshaft supporting part without increasing the overall length of the engine and without compromising the securing of the cylinder-head bolts. Further, the oil control valve can be made easily serviced by exposing it on the outside of the engine without requiring a special seal component.

[Figure 8]



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EUROPEAN SEARCH REPORT

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| Place of search THE HAGUE | | Date of completion of the search 17 April 2000 | Examiner Paquay, J |
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